
SYLLABUS

FOR

M.SC. (TWO-YEAR) PROGRAMME

IN MATHEMATICS

Under the provisions of the National Education Policy (NEP) 2020

Effective from the academic session 2026-2027



KAZI NAZRUL UNIVERSITY

ASANSOL-713 340

WEST BENGAL

Preamble

The purpose of a Learning Outcome-based Curriculum Framework (LOCF) is to change the paradigm of higher education from a teacher-centric to learner-centric curriculum. The LOCF for the Postgraduate Programme in Mathematics is developed in alignment with the vision of the National Education Policy (NEP) 2020 and the academic guidelines of the University Grants Commission (UGC). The framework emphasizes outcome-based learning, academic flexibility, multidisciplinary integration, research orientation, computational proficiency, and integration of Indian Knowledge Systems (IKS). It is hoped that this paradigmatic change will bring about a significant improvement in the quality of higher education and make the learners both competent and confident to face the challenges of a modern competitive world.

Mathematics, being the foundational discipline for science, technology, engineering, data science, economics, and emerging interdisciplinary areas, requires a curriculum that balances rigorous theoretical foundations with modern computational and applied techniques. This LOCF-based curriculum is designed to:

- i. Promote deep conceptual understanding in pure and applied mathematics.
- ii. Develop analytical, logical, and problem-solving abilities of learners.
- iii. Integrate computational tools and numerical methods for real-world problem solving.
- iv. Encourage research aptitude and mathematical modelling skills.
- v. Incorporate the rich heritage of Indian mathematical traditions within modern contexts.
- vi. Prepare students for careers in academia, research, industry, data science, and technology sectors.

Postgraduate Attributes:

Postgraduate programme in Mathematics will develop the following attributes:

1. Disciplinary Knowledge – Mastery of advanced mathematical theories and methods.
2. Analytical Reasoning – Ability to construct rigorous proofs and logical arguments.
3. Problem Solving – Application of mathematical tools to real-world problems.
4. Computational Proficiency – Use of numerical methods, algorithms, and software tools.
5. Research Competence – Ability to read, understand, and contribute to mathematical research.
6. Communication Skills– Express thoughts and ideas effectively in writing and orally, communicate with others using appropriate media.
7. Collaboration/Cooperation/Team work–Demonstrate ability to work effectively and respectfully and efficiently as a member of a team.
8. Interdisciplinary Capability – Application of mathematics in physics, engineering, data science, and finance.
9. Ethical and Professional Responsibility – Academic integrity and professional conduct.
10. Indian Knowledge Awareness – Appreciation of classical Indian contributions to mathematics.

Program Outcomes (POs):

On successful completion of the m.sc in mathematics programme, the students will be able to:

PO1	Advanced Mathematical Competence: Acquire in-depth understanding of core areas of pure and applied mathematics, including, algebra, analysis, geometry, topology, mechanics, differential equations, optimization, and computational mathematics.
PO2	Critical Thinking and Problem Analysis: <i>Inculcate critical thinking</i> to identify the problems and formulate various methodologies for obtaining their solutions.
PO3	Computational Proficiency: Develop proficiency in modern computational tools and programming languages for solving mathematical and interdisciplinary problems.
PO4	Research and Communication Skills: Gain proficiency in mathematical writing, literature review, and research methodology. Communicate mathematical ideas, proofs, algorithms, and research findings effectively through written, oral, and digital formats.
PO5	Teamwork and Collaboration: Work effectively both independently and collaboratively in academic, professional, and research environments.
PO6	Ethics and Knowledge Systems: Recognize ethical principles, professional responsibilities, and the significance of Indian Knowledge Systems (IKS) and cultural heritage in the development of mathematics.
PO7	Lifelong Learning and Interdisciplinary Outlook: Engage in lifelong learning to stay updated with emerging areas in mathematics such as, data-driven mathematics, mathematical computing and integrate mathematical knowledge with other scientific and engineering domains.
PO8	Employability and Entrepreneurship: Demonstrate employability for teaching profession in schools/colleges/universities/institutes, government jobs, jobs in banking, insurance and entrepreneurship skills investment sectors, data analyst and jobs in various other public and private enterprises.

Program Specific Outcomes (PSOs):

After the successful completion of M.Sc. in Mathematics programme, the students are expected to:

PSO1	Apply advanced mathematical concepts from algebra, analysis, mechanics, geometry, optimization, differential equations, functional analysis, and topology to theoretical and practical problems.
PSO2	Use computational and algorithmic methods, including programming in MATLAB, Python, data science techniques, graph theory, and numerical methods, to solve complex mathematical models.
PSO3	Conduct independent research and projects in areas like fuzzy mathematics, analysis, operations research, AI and machine learning, data science, decision science and mathematical modelling in applied sciences.
PSO4	Appreciate the historical and cultural development of mathematics, including Indian Knowledge Systems, and apply mathematical knowledge to the solution of the real life problems in multidisciplinary areas.

Assessment Scheme

- i. All theory courses in the programme shall carry a Continuous Assessment (CA) component carrying **30%** of the total marks and an End-Semester Examination (ESE) carrying **70%** of the total marks. The minimum pass marks for each course shall be 40% of the aggregate marks obtained in CA and ESE taken together.
- ii. All Laboratory/Practical/Project components shall carry a CA component carrying **60%** of the total marks and an ESE carrying **40%** of the total marks. The minimum pass marks for each course shall be 40% of the aggregate marks obtained in CA and ESE taken together.
- iii. The End-Semester Examination (ESE) shall be conducted by the University in accordance with the applicable Kazi Nazrul University (KNU) regulations.
- iv. For a 30-mark Continuous Assessment (CA), there shall be two written internal examinations in each course during the semester. Each examination shall be of **one-hour duration** and carry **20 marks**. For the purpose of computation of CA marks, the **better of the two scores** shall be considered for computation of marks out of **20 marks**. The remaining **10 marks** shall be awarded as follows: **5 marks** for assignments/viva-voce/presentations/open-book examinations/computational work/project work/quizzes, and **5 marks** for punctuality and class attendance.
- v. For a 15-mark Continuous Assessment (CA), there shall be two written internal examinations in each course per semester. Each examination shall be of **30 minutes' duration** and carry **10 marks**. For the purpose of computation of CA marks, the **better of the two scores** shall be considered for the computation of marks out of **10 marks**. The remaining **5 marks** shall be awarded for punctuality and class attendance.

Marks for the Attendance will be considered as follows:

SL. NO.	ATTENDANCE %	MARKS
1	Above 90%	5
2	80-90%	4
3	Below 80%	3

Format of question paper of 20 marks (or 10 marks) for Continuous Assessment

M.Sc. Semester Continuous Assessment-I/II, ...(Year).....	
Discipline: Mathematics	
Course Type: -----	
Course code: -----	
Course name: -----	
Full marks: 20(or 10)	Time: 1(or ½) hour

1. Answer all five questions:	2×5=10 (or 1×5=5)
2. Answer any one question:	10×1=10 (or 5×1=5)
a.	
b.	
Note: There may be subdivisions in each question	

Course Structure

Semester	Course Code	Course Name	Credit	Marks	
Semester I	MSCMTMMC101	Abstract Algebra	5	100	
	MSCMTMMC102	Topology	5	100	
	MSCMTMMC103	Ordinary Differential Equations and Special Functions	5	100	
	MSCMTMMC104	Integral Transforms and Integral Equations	5	100	
	Minor Elective 1				
	MSCMTMMN101	Mathematical Logic and Set Theory	5	100	
Total			25	500	
Semester II	MSCMTMMC201	Functional Analysis	5	100	
	MSCMTMMC202	Differential Geometry	5	100	
	MSCMTMMC203	Classical Mechanics and Variational Calculus	5	100	
	MSCMTMMC204	Operations Research	5	100	
	Minor Elective 2				
	MSCMTMMN201	Graph Theory	5	100	
Total			25	500	
Semester III					
Total			20	400	
Semester IV					
Total			20	400	
Grand Total			90	1800	

Detailed Syllabus

SEMESTER-I

Major coursework-1

Go to Course Structure

Course Code: MSCMTMMC101	Course Name: Abstract Algebra			
Course Type: MAJOR COURSEWORK (Theoretical)	Course Details: MC-1		L-T-P: 4-1-0	
Credit: 5	Full Marks: 100	CA Marks		ESE Marks
		Practical	Theoretical	Practical Theoretical
		.....	30	 70

Pre-requisite of course	A basic knowledge of abstract algebra.		
Course Objectives			
The objectives of this course are to:			
1. Develop a fundamental understanding of groups, subgroups, homomorphisms, group actions, and the structure of finite groups.			
2. Introduce the basic concepts of rings, ideals, quotient rings, homomorphisms, and factorization domains.			
3. Develop an understanding of polynomial rings, irreducibility criteria, and unique factorization.			
4. Familiarize students with field extensions, algebraic closures, splitting fields, and finite fields.			
Course Outcomes (COs)			
Upon successful completion of this course, students will be able to:			
CO1	Analyze groups using homomorphisms, automorphisms, direct products, and group actions.		
CO2	Apply conjugacy, class equations, Sylow theorems, and related results to study finite and abelian groups.		
CO3	Analyze rings using ideals, quotient rings, homomorphisms, isomorphism theorems, and factorization properties.		
CO4	Apply polynomial and field theory concepts to study factorization, field extensions, splitting fields, and finite fields.		
Course content			Contact Hours
Unit-1	Group homomorphisms, Cayley’s theorem, extended Cayley’s theorem. Direct product of groups, Cauchy’s theorem on finite groups, p -group, Centre of p -groups. Automorphism, inner automorphism, Characteristic subgroups, Commutator subgroup and its properties. Group actions, orbits, stabilizers and kernels, Orbit-stabilizer Theorem, permutation representation associated with a given group action. Applications of group actions.		20
Unit-2	Groups acting on themselves by conjugation, class equation and consequences, conjugacy in S_n , p -groups, Sylow’s theorems and consequences, Cauchy’s theorem, Finite Simple Groups,		10

	Simplicity of A_n for $n \geq 5$, non-simplicity tests of groups of order p^n ($n > 1$), pq, p^2q, p^2q^2 (p, q are primes), Finitely generated Abelian groups.	
Unit-3	Definition, examples and elementary properties of rings, commutative rings, Integral domain, division rings and fields, characteristic of a ring, Boolean ring, direct sum of rings, ideals and quotient rings, ring homomorphisms and isomorphisms, isomorphism theorems, prime, principal and maximal ideals, Relation between prime and maximal ideals, ring of fractions.	20
Unit-4	Polynomial rings over commutative ring and their basic properties, The division algorithm; Gauss lemma and Eisenstein's irreducibility criterion, Euclidean domain, principal ideal domain, and unique factorization domain.	10
Unit-5	Field extensions-algebraic and transcendental extensions, finite extension, Algebraic closure of a field, algebraically closed field, Splitting field of a polynomial, multiple roots, finite fields and their properties.	15
Total Contact Hours		75

Text Books

1. D. S. Malik, J. M. Mordeson, M. K. Sen, Fundamentals of abstract algebra, The McGraw-Hill Companies, Inc.
2. D. S. Dummit, R. M. Foote, Abstract algebra, John Wiley and Sons.
3. I. N. Herstein, Topics in Algebra, Wiley Eastern Limited, India.
4. J. A. Gallian, Contemporary abstract algebra, Cengage learning India pvt. Ltd.

Reference Books

1. J. B. Fraleigh, A first course in abstract algebra, Pearson education.
2. M. Artin, Algebra, Pearson education.
3. T. W. Hungerford, Algebra, Springer-Verlag.
4. N. Jacobson, Basic Algebra I & II (2nd edition), Dover Publications, Inc.
5. Serge Lang, Algebra, 3rd Ed, Springer-Verlag.
6. P. B. Bhattacharya, S. K. Jain & S.R. Nagpaul, Basic Abstract Algebra, 2nd Ed., Cambridge University Press.
7. J. R. Durbin, Modern Algebra, John Wiley & Sons, New York Inc.

CO–PO–PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	H	H	L	L	L	—	M	L	H	L	H	M
CO2	H	H	L	L	L	—	H	L	H	L	H	M
CO3	H	H	L	L	L	—	M	L	H	L	H	M
CO4	H	H	M	L	L	—	H	M	H	M	H	H

Major coursework-2

[Go to Course Structure](#)

Course Code: MSCMTMMC102	Course Name: Topology			
Course Type: MAJOR COURSEWORK (Theoretical)	Course Details: MC-2		L-T-P: 4-1-0	
Credit: 5	Full Marks: 100	CA Marks		ESE Marks
		Practical	Theoretical	Practical Theoretical
			30	 70

Pre-requisite of course	A basic knowledge of real analysis.
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Course Objectives

The objectives of this course are to:

1. Develop a fundamental understanding of topological spaces, bases, continuity, and related topological concepts.
2. Introduce separation and countability axioms and examine their properties and interrelationships.
3. Develop an understanding of compactness and its characterizations in topological spaces.
4. Familiarize students with connectedness, path connectedness, and their various forms and properties.

Course Outcomes (COs)

Upon successful completion of this course, students will be able to:

CO1	Analyze topological spaces using bases, continuity, closure, interior, product, and quotient topologies.
CO2	Apply separation and countability axioms to characterize and compare topological spaces.
CO3	Analyze compactness using its characterizations, subspaces, continuous functions, and related properties.
CO4	Apply concepts of connectedness and path connectedness to investigate the structure and properties of topological spaces.

Course content		Contact Hours
Unit-1	Topological spaces: Definition and examples of topological spaces, Open sets, Neighbourhoods, Neighbourhood systems, Neighbourhood operator, Generation of a topology using neighbourhood operators, Bases, Subbases, Limit points, Derived sets, Closure of a set, Closed sets, Kuratowski closure operator, Interior of a set, Continuous functions, Open maps, Closed maps, Homeomorphism and topological invariants, Product topological spaces, quotient topological space.	20
Unit-2	Separation axioms: T_0 spaces, T_1 spaces, T_2 spaces, Regular spaces, T_3 spaces, Normal spaces, T_4 spaces, Uryshon's lemma (Statement only), Completely regular spaces and $T_{3.5}$ spaces, their properties, characterizations and relationships. Tietze's extension theorem (Statement only).	15

Unit-3	Countability axioms: First and second countable spaces, Separable spaces, Lindelöf space, Examples and their mutual relations, Properties on continuity and subspaces of the above spaces.	10
Unit-4	Compactness: Compact spaces, compact subspaces, characterizations in terms of finite intersection property, Alexander subbase theorem, compactness and separation axioms, compactness and continuous functions, sequentially, Fréchet and countably compact spaces, subspaces and their mutual relationship, locally compact spaces.	20
Unit-5	Connectedness: Connected spaces and their characterizations, Connected subspaces, Connectedness of the real line, Components, Totally disconnected spaces, Locally connected spaces, Path connectedness, Path components, Locally path connected spaces.	10
Total Contact Hours		75
Text Books		
1. J. L. Kelly: General Topology, Harper Collins 2. G.F. Simmons, Introduction to Topology and Modern Analysis. McGraw Hill. 3. K. D. Joshi: Introduction to General Topology. New Age International Publications 4. J. R. Munkres, Topology: A first course. Prentice Hall, India.		
Reference Books		
1. L.A. Steen and J.A. Seebach, Counterexamples in Topology. Dover Publication, Inc. New York. 2. B.C. Chatterjee, M. R. Adhikari and S. Ganguly, A text book of Topology. Asian Books. 3. W. J. Thron, Topological Structures; Holt, Rinehart and Winston, Inc., New York. 4. P. R. Halmos, Naïve Set Theory, Dover Publication.		

CO–PO–PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	H	H	L	L	L	—	M	L	H	L	M	M
CO2	H	H	L	L	L	—	M	L	H	L	H	M
CO3	H	H	L	L	L	—	H	L	H	M	H	M
CO4	H	H	L	L	L	—	M	L	H	L	H	M

Major coursework-3

[Go to Course Structure](#)

Course Code: MSCMTMMC103	Course Name: Ordinary Differential Equations and Special Functions				
Course Type: MAJOR COURSEWORK (Theoretical)	Course Details: MC-3		L-T-P: 4-1-0		
Credit: 5	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		.....	30	.....	70

Pre-requisite of course	A basic knowledge of ordinary differential equations, linear algebra, and calculus.		
Course Objectives			
The objectives of this course are to:			
1. Develop an understanding of linear and nonlinear systems of differential equations and their solution methods.			
2. Introduce qualitative analysis, stability theory, and boundary value problems for differential equations.			
3. Develop techniques for series solutions of differential equations, including the Frobenius method.			
4. Familiarize students with classical special functions, including Legendre, Bessel, Hermite, Laguerre, and hypergeometric functions.			
Course Outcomes (COs)			
Upon successful completion of this course, students will be able to:			
CO1	Solve systems of linear differential equations using matrix methods and analyze nonlinear systems through phase-plane and stability techniques.		
CO2	Formulate and analyze boundary value and Sturm–Liouville problems using eigenvalues, eigenfunctions, and Green’s functions.		
CO3	Apply power series and Frobenius methods to obtain solutions of differential equations about ordinary and regular singular points.		
CO4	Analyze the properties of Legendre, Bessel, Hermite, Laguerre, and hypergeometric functions using generating functions, recurrence relations, and orthogonality properties.		
Course content			Contact Hours
Unit-1	System of linear differential equations: Homogeneous and non-homogeneous linear systems, Linear systems with constant coefficients and their solution by matrix method, Linear equations with periodic coefficients.		10
Unit-2	Non-linear differential equations: Autonomous system, Phase plane analysis, Qualitative solutions, Critical Points, Types of critical points, Stability of the critical points, Linearization, Liapunov stability, Limit cycles.		10
Unit-3	Boundary value problems: Construction of two-point boundary value problems, Sturm-Liouville problems, Eigenfunctions and eigenvalues, Orthogonality of eigenfunctions, Completeness of the eigenfunctions, Green's functions, Construction of Green's functions for		15

	both homogeneous and nonhomogeneous boundary conditions	
Unit-4	Power series solution of a differential equation about an ordinary point, solution about a regular singular point. Frobenius method, Legendre's equation, its solution, Legendre polynomials, Rodrigues formula, orthogonality, recurrence relations, Bessel's equation, Bessel functions, recurrence relations, generating function and orthogonality properties of Bessel function.	20
Unit-5	Hermite polynomials: generating functions, orthogonal properties, recurrence relations of Hermite polynomials. Laguerre polynomials: generating functions, orthogonal properties of Laguerre polynomials, Relation between Laguerre polynomial and their derivatives. Hypergeometric function, Gauss's hypergeometric equation and its solution, Symmetric property of hypergeometric function, Differentiation and integral representation of hypergeometric function.	20
Total Contact Hours		75
Text Books		
1. D. W. Jordan and P. Smith, Nonlinear Ordinary Differential Equations: Problems and Solutions, Oxford University Press. 2. E. D. Rainville, Special Functions, Macmillan. 3. N. N. Lebedev, Special Functions and Their Applications. 4. P. Hartman, Ordinary Differential Equation, John Wiley and Sons.		
Reference Books		
1. S. L. Ross, Ordinary Differential Equations, John Wiley & Sons 2. A. Chakraborty, Elements of ordinary differential equations and special functions, New Age India International. 3. R. P. Agarwal and D. O'Regan, Introduction to ordinary differential equations, Springer 4. R. K. Jain & S.R.K. Iyengar, Advanced Engineering Mathematics, Narosa. 5. G. Arfken, H. Weber & Harris, Mathematical Methods for Physicists, Elsevier		

CO–PO–PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	L	L	—	H	M	H	M	H	H
CO2	H	H	M	L	L	—	H	M	H	M	H	H
CO3	H	H	L	L	L	—	M	L	H	L	M	M
CO4	H	H	M	L	L	—	H	M	H	M	H	H

Major coursework-4

[Go to Course Structure](#)

Course Code: MSCMTMMC104	Course Name: Integral Transforms and Integral Equations				
Course Type: MAJOR COURSEWORK (Theoretical)	Course Details: MC-4		L-T-P: 4-1-0		
Credit: 5	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		.....	30	.....	70

Pre-requisite of course	A basic knowledge of calculus, ordinary differential equations, and linear algebra.
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Course Objectives

The objectives of this course are to:

1. Develop an understanding of Fourier, Laplace, and Z-transforms and their properties.
2. Introduce integral equations and their classification, kernels, eigenvalues, and eigenfunctions.
3. Develop analytical techniques for solving Volterra and Fredholm integral equations.
4. Familiarize students with symmetric, convolution-type, and singular integral equations and their applications.

Course Outcomes (COs)

Upon successful completion of this course, students will be able to:

CO1	Understand the fundamental concepts, properties, and theoretical foundations of Fourier transforms, Laplace transforms, Z-transforms and integral equations.
CO2	Apply Fourier and Laplace transform techniques to solve ordinary and partial differential equations arising in mathematical, physical, and engineering problems.
CO3	Classify and formulate various types of integral equations and apply successive approximation, successive substitution, resolvent kernel, and iterated kernel methods to solve integral equations
CO4	Determine eigenvalues and eigenfunctions associated with integral equations and analyze integral equations with symmetric, convolution-type, and singular kernels, including Abel's integral equation.

Course content		Contact Hours
Unit-1	Fourier Transforms: Fourier Transforms as a limit of Fourier Series. Fourier Integral Theorem (statement only). Determination of Fourier Transform Pairs from Fourier Integral. Definition and properties of Fourier Transforms: Linearity, Change of Scale Property, Shifting Property, Modulation theorem. Fourier Transforms of Derivatives, Fourier Transforms of some useful functions. Fourier sine and cosine transforms. Inverse Fourier Transform and examples. Convolution Theorem, Parseval's relation, Application of Fourier transforms to solving ordinary and partial differential equations.	15
Unit-2	Laplace Transforms: Definition of Laplace Transform. Derivation of Laplace Transform from Fourier Integral and its relation with Fourier Transform. Laplace Transform of some elementary functions. Sufficient conditions for the existence of Laplace Transform (statement only) with counter examples. Properties of Laplace transforms: Linearity, First	15

	Shifting Property, Change of Scale Property, Laplace transforms of periodic functions, Second Shifting Property, Laplace transforms of derivatives and integrals. Statements of Initial and final value theorems. Inverse Laplace Transform: Definition and examples. Statement and applications of Convolution theorem. Application to Ordinary differential equations, Partial differential equations and linear integral equations.	
Unit-3	Z-Transform: Definition and properties. Properties of Z-transform, Z-transform of some standard functions. Theorems on Z-transform, Differentiation, Convolution theorem, Inverse Z-transforms. Applications.	5
Unit-4	Preliminary concepts of integral equations, Linear integral equations, Classification of linear integral equations, Volterra integral equations, Fredholm integral equations, conversion of initial and boundary value problems to integral equations and vice-versa, Different types of kernels, Integral equations with degenerate kernels, Homogeneous Fredholm integral equations, Fredholm theorems, Eigenvalue and eigenfunction of integral equation and their simple properties.	15
Unit-5	Existence and uniqueness of continuous solutions of Fredholm and Volterra's integral equations of second kind, Solution by the method of successive approximations, The method of successive substitutions, Resolvent kernel method, Iterated kernel method, Solution of Volterra integral equation of first kind.	15
Unit-6	Integral equations with symmetric kernels, Orthogonal system of functions, fundamental properties of eigenvalues and eigenfunctions for symmetric kernels. Solution of Volterra integral equations with convolution type kernels. Singular integral equation, Solution of Abel's integral equation.	10
Total Contact Hours		75

Text Books

1. L. Debnath and D. Bhatta, Integral Transforms and their Applications. Chapman and Hall/CRC.
2. L. C. Andrews and B. K. Shivamoggi, Integral Transforms for Engineers (Vol. 66). SPIE Press.
3. W. V. Lovitt, Linear Integral Equations. Dover Publications.
4. R. P. Kanwal, Linear Integral Equations. 2nd edition, Birkhäuser

Reference Books

1. A. Pinkus and S. Zafrany, Fourier Series and Integral Transforms. Cambridge University Press.
2. E. Kreyszig, Advanced Engineering Mathematics (10th edition). Wiley.
3. A. Chakraborti, Applied Integral Equation, Vijay Nicole Imprints Pvt Ltd.
4. M. Rahman, Integral Equations and their Applications, WIT Press, Boston.

CO-PO-PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	L	L	—	M	L	H	M	M	M
CO2	H	H	M	L	M	—	H	H	H	H	H	H
CO3	H	H	M	M	L	—	H	M	H	M	H	H
CO4	H	H	M	L	L	—	H	M	H	M	H	H

Minor course-1

[Go to Course Structure](#)

Course Code: MSCMTMMN101	Course Name: Mathematical Logic and Set Theory				
Course Type: MINOR COURSE (Theoretical)	Course Details: MN-1			L-T-P: 4-1-0	
Credit: 5	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		.....	30	.....	70

Pre-requisite of course	A basic knowledge of set theory and mathematical reasoning.		
Course Objectives			
The objectives of this course are to:			
1. Develop an understanding of mathematical logic, first-order languages, structures, and formal proofs. 2. Introduce completeness, compactness, consistency, and their applications in mathematics. 3. Develop fundamental concepts of sets, relations, mappings, and cardinality. 4. Familiarize students with partially ordered sets and lattice structures and their properties.			
Course Outcomes (COs)			
Upon successful completion of this course, students will be able to:			
CO1	Understand the syntax of first-order logic and semantics of first-order languages and apply propositional and first-order logic, including predicates, quantifiers, structures, and formal proofs.		
CO2	Understand about truth table, different propositions, predicates and quantifiers, basic Theorems like the Compactness Theorem, Meta Theorem and Post Tautology Theorem.		
CO3	Grasp the concept basic set theory, partially ordered set, lattices and apply set-theoretic concepts involving relations, mappings, Cartesian products, and cardinality.		
CO4	Model and solve simple logical problems exploiting the techniques presented in the course.		
Course content			Contact Hours
Unit-1	Mathematical Logic: First-order languages, Terms of a language, Formulas of language, first order theory. Structures of first order languages, Truth in a structure, Model of a theory, Embeddings and isomorphism. Introduction, propositions, truth table, negation, conjunction and disjunction. Implications, biconditional propositions, converse, contra positive and inverse propositions and precedence of logical operators. Propositional equivalence: Logical equivalences. Predicates and quantifiers: Introduction, Quantifiers, Binding variables and Negations.		25
Unit-2	Proof in first-order logic, Meta theorems in first order logic, Some meta theorem in arithmetic, Consistency and completeness. Completeness theorem, Interpretation in a theory,		20

	Extension by definitions, Compactness theorem and its applications, complete theories, Applications in algebra.	
Unit-3	Set: Definition, example, subsets, union, intersection, universal set, complement of a set, difference, symmetric difference, Venn diagrams, De Morgan's Laws, cardinality, Cartesian product of sets, relation, mappings.	10
Unit-4	Partially Ordered Sets: Definitions, examples and basic properties of partially ordered sets (poset), Order isomorphism, Hasse diagrams, Dual of a poset, Duality principle, Maximal and minimal elements, Least upper bound and greatest upper bound, Building new poset, Maps between posets.	10
Unit-5	Lattices: Lattices as posets, Lattices as algebraic structures, sublattices, Products and homomorphisms; Definitions, examples and properties of modular and distributive lattices; Complemented, relatively complemented and sectionally complemented lattices.	10
Total Contact Hours		75
Text Books		
1. R. E. Hodel, An Introduction to Mathematical Logic, Dover Publications, 2013. 2. R. R. Stoll, Set Theory and Logic, Dover Publications, Inc, New York, 1963.		
Reference Books		
1. Yu I. Manin, A Course in Mathematical Logic for Mathematicians, Springer, 2nd Edition, 2010. 2. E. Mendelson, Introduction to Mathematical Logic, Chapman & Hall/CRC, 6th Edition, 2015. 3. S. M. Srivastava, A Course in Mathematical Logic, Springer, 2nd Edition, Springer, 2013. 4. R. P. Grimaldi, Discrete Mathematics and Combinatorial Mathematics, Pearson Education, 1998 5. A. G. Hamilton, Logic for Mathematicians, Cambridge University Press, 1988.		

CO–PO–PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	H	H	L	L	L	—	M	L	H	L	M	L
CO2	H	H	L	L	L	—	M	L	H	L	M	L
CO3	H	H	L	L	L	—	M	L	H	L	M	M
CO4	M	H	L	L	L	—	M	M	M	L	M	M

SEMESTER-II

Major coursework-5

[Go to Course Structure](#)

Course Code: MSCMTMMC201	Course Name: Functional Analysis				
Course Type: MAJOR COURSEWORK (Theoretical)	Course Details: MC-5		L-T-P: 4-1-0		
Credit: 5	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		.....	30	.....	70

Pre-requisite of course	A basic knowledge of real analysis, linear algebra, metric spaces, and elementary topology.
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Course Objectives

The objectives of this course are to:

1. Develop a rigorous understanding of normed, Banach, inner product, and Hilbert spaces.
2. Introduce fundamental theorems of functional analysis and their applications to linear operators and functionals.
3. Develop an understanding of orthogonality, projection, duality, and operator theory in Hilbert spaces.
4. Familiarize students with bounded linear operators and their spectral properties.

Course Outcomes (COs)

Upon successful completion of this course, students will be able to:

CO1	Understand the fundamental concepts and structures of normed linear spaces, Banach spaces, inner product spaces, and Hilbert spaces.
CO2	Apply major theorems of functional analysis, including the Hahn–Banach, Uniform Boundedness, Open Mapping, and Closed Graph theorems.
CO3	Investigate the properties of bounded linear operators, dual spaces, quotient spaces, and reflexive spaces within the framework of Banach and Hilbert spaces.
CO4	Analyze bounded linear operators and their special classes through spectral properties, including the spectrum, resolvent, and spectral radius.

Course content

Contact Hours

Unit-1	Banach Spaces: Normed Linear Spaces with some properties, Banach Spaces and its examples, Equivalent Norms, Finite dimensional normed linear spaces, Compactness of closed bounded sets with special reference to the closed unit ball, Quotient Space of normed linear spaces and its completeness, Riesz Lemma. Bounded Linear Transformations, Uniform Boundedness principle, Open Mapping Theorem, Closed Graph Theorem, Linear	30
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	Functionals, Hahn-Banach Theorem, Dual Space, Reflexivity of Banach Spaces.	
Unit-2	Inner Product Spaces: Inner product spaces with examples, Parallelogram law, polarization identity, Cauchy-Schwarz inequality, orthogonality, orthonormal vectors, complete orthonormal set of vectors, Pythagorean Theorem, Gram-Schmidt orthogonalization process, Bessel's Inequality, Parseval's Identity.	15
Unit-3	Hilbert Spaces: Hilbert Spaces with examples, Orthogonal Complement and Projection Theorem. Riesz Representation Theorem, Reflexivity of Hilbert Spaces, Adjoint of an Operator on a Hilbert Space, Self-adjoint Operators, Positive Operators, Projection Operators, Normal Operators, Unitary Operators. Introduction to Spectral Properties of Bounded Linear Operators. Resolvent set, spectrum and spectral radius of operators on Banach space, spectral mapping theorem for polynomials.	30
Total Contact Hours		75
Text Books		
1. Simmons, G.F., Introduction to Topology and Modern analysis, McGraw-Hill. 2. Kreyszig, E., Introductory Functional Analysis with Applications, John Wiley and Sons (Asia) Pvt. Ltd. 3. Aliprantis, C.D., Burkinshaw, O., Principles of Real Analysis, 3rd Edition, Harcourt Asia Pvt Ltd. 4. Limaye, B.V., Functional Analysis, Wiley Eastern Ltd.		
Reference Books		
1. Goffman, C., Pedrick, G., First Course in Functional Analysis, PHI, New Delhi. 2. Bachman, G., Narici, L., Functional Analysis, Academic Press. 3. Taylor, A.E. Introduction to Functional Analysis, John Wiley and Sons, New York. 4. Conway, J.B., A course in Functional Analysis, Springer-Verlag, New York. 5. Ponnusamy, S., Foundations of Functional Analysis, Narosa. 6. Lahiri, B.K., Elements of Functional Analysis, World Press.		

CO–PO–PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	H	H	L	L	L	—	M	L	H	L	M	L
CO2	H	H	M	M	L	—	H	M	H	M	H	M
CO3	H	H	M	L	L	—	H	M	H	M	H	M
CO4	H	H	M	L	L	—	H	M	H	M	H	M

Major coursework-6

[Go to Course Structure](#)

Course Code: MSCMTMMC202	Course Name: Differential Geometry			
Course Type: MAJOR COURSEWORK (Theoretical)	Course Details: MC-6		L-T-P: 4-1-0	
Credit: 5	Full Marks: 100	CA Marks		ESE Marks
		Practical	Theoretical	Practical Theoretical
		.....	30	 70

Pre-requisite of course	A basic knowledge of multivariable calculus, linear algebra, differential equations, and real analysis.
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Course Objectives

The objectives of this course are to:

1. Develop an understanding of Riemannian spaces, tensor calculus, covariant differentiation, and curvature.
2. Introduce the differential geometry of space curves and their geometric properties.
3. Develop the concepts of curves and surfaces, including geodesics and intrinsic geometry.
4. Familiarize students with the fundamental forms, curvatures, and geometric properties of surfaces.

Course Outcomes (COs)

Upon successful completion of this course, students will be able to:

CO1	Understand the fundamental concepts of Riemannian geometry, covariant differentiation, and curvature tensors in curved spaces.
CO2	Apply tensor methods and differential geometric techniques to analyze geometric properties of Riemannian spaces and spaces of constant curvature.
CO3	Investigate the geometry of space curves through curvature, torsion, Frenet–Serret theory, and related concepts such as helices, evolutes, and involutes.
CO4	Analyze the intrinsic and extrinsic geometry of surfaces using fundamental forms, geodesics, Gaussian curvature, and surface transformations.

Course content		Contact Hours
Unit-1	Riemannian space, Covariant Differentiation of Covariant and Contravariant vectors and of Tensors, of fundamental tensors of Kronecker delta, Algebra of covariant differentiation, Gradient, divergence, curl and Laplacian, Riemann-Christoffel Curvature Tensor and its contraction, Ricci Tensor, Flat space, Bianchi identity, permutation tensors, Curl of a covariant vector, vector product of two covariant vector, intrinsic differentiation, space of constant curvature.	15
Unit-2	Theory of Space Curves: Space curves, representation of space curves, parametric form, Planer curves, Arc length, tangent and osculating plane, principal normal and binormal, Curvature and torsion, Serret-Frenet formula, contact between curves and surfaces, osculating circles and spheres, locus of centres of spherical curvature, Bertrand curves,	20

	intrinsic equation of space curves, Helices, tangent surfaces, evolutes and involutes of curves, fundamental existence and uniqueness theorem for space curves.	
Unit-3	Theory of Surfaces: Representation of a surface, curves on surfaces, direction coefficients, tangent planes and normal surfaces, the general surfaces of revolution, Helicoids, families of curves, orthogonal trajectories, Metric on a surface: First fundamental forms, Geodesics and their properties, Geodesic parallels, Geodesic and Gaussian curvatures, Isometries, Gauss-Bonnet theorem, Surfaces of constant Gaussian Curvature.	20
Unit-4	Second fundamental form, principal, normal, total and mean curvature, Meusnier's theorem, Lines of curvature, Developable surfaces, Minimal surfaces, Ruled surfaces, Third fundamental form, Gauss and Weingarten Formulae, Mainardi-Codazzi equations, Euler's theorem, Rodrigues formula, Conjugate and Asymptotic lines, The fundamental existence theorem for Surfaces.	20
Total Contact Hours		75

Text Books

1. Pressely, Andrew, Elementary differential Geometry, Springer.
2. Willmore, T.J., An Introduction to Differential Geometry, Oxford University Press.
3. B. O'Neill, Elementary Differential Geometry, 2nd Ed., Academic Press.
4. S. Lang, Fundamentals of Differential Geometry, Springer.

Reference Books

1. Carmo, M. P. do: Differential geometry of curves and surfaces, Prentice-Hall Inc.
2. Singer, I. M. and Thorpe, J. A., Lecture notes on elementary topology and geometry, Springer.
3. Spivak, M., A comprehensive introduction to differential geometry, Vol. I, Publish or Perish Inc., Houston.
4. Eisenhart, L.P., An introduction to Differential Geometry, Princeton University Press.
5. D. J. Struik, Lectures on Classical Differential Geometry, Dover Publications.
6. Christian Bär, Elementary Differential Geometry, Cambridge University Press.

CO-PO-PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	L	L	—	M	L	H	M	M	M
CO2	H	H	M	L	L	—	H	M	H	M	H	M
CO3	H	H	L	L	L	—	M	M	H	L	M	M
CO4	H	H	M	L	L	—	H	M	H	M	H	H

Major coursework-7

[Go to Course Structure](#)

Course Code: MSCMTMMC203	Course Name: Classical Mechanics and Variational Calculus				
Course Type: MAJOR COURSEWORK (Theoretical)	Course Details: MC-7		L-T-P: 4-1-0		
Credit: 5	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		.....	30	.....	70

Pre-requisite of course	A basic knowledge of mechanics, multivariable calculus, differential equations, and linear algebra.
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Course Objectives

The objectives of this course are to:

1. Develop an understanding of constrained mechanical systems and generalized coordinates.
2. Introduce Lagrangian and Hamiltonian formulations of classical mechanics.
3. Develop the concepts of canonical transformations, Poisson brackets, and Hamilton–Jacobi theory.
4. Familiarize students with variational principles and analytical methods for solving variational problems.

Course Outcomes (COs)

Upon successful completion of this course, students will be able to:

CO1	Understand the fundamental concepts of generalized coordinates, generalized forces, and degrees of freedom.
CO2	Formulate and solve equations of motion using Lagrangian and Hamiltonian approaches for holonomic and non-holonomic dynamical systems.
CO3	Apply variational principles such as Hamilton’s principle, the principle of least action, and the principle of energy to derive and analyze dynamical equations.
CO4	Analyze canonical transformations, generating functions, Poisson brackets, and Hamilton–Jacobi theory in the study of dynamical systems.
CO5	To understand the concept of Calculus of Variations and its applications.

Course content		Contact Hours
Unit-1	Constraints, Types of constraints, unilateral, bilateral, holonomic, scleronomic, rheonomic constraints, Degrees of freedom, Generalised coordinates, Forces of constraints, Generalised forces and generalized momentum, Expression for kinetic energy.	10
Unit-2	Lagrange’s equation of motion of the first kind, Lagrange’s equations of motion of the second kind (holonomic and non-holonomic systems); Velocity dependent potential, Dissipative forces, Rayleigh’s dissipation function.	10

Unit-3	Cyclic coordinates, Routh's process for the ignoration of coordinates and applications, Legendre dual transformation, Hamilton's canonical equations of motion.	10
Unit-4	Action Integral, Hamilton's principle for conservative, non-holonomic system, Hamilton's principle for non-conservative, non-holonomic system, derivation of Hamilton's principle from Lagrange's equations, derivation of Lagrange's equations from Hamilton's principle, Principle of least action, Principle of energy	15
Unit-5	Definition, examples and properties of canonical transformations; Generating functions; Lagrangian and Poisson brackets (definition and properties); Invariance of Poisson and Lagrange brackets under canonical transformations, Poisson's theorems; Condition of canonicity in terms of Poisson bracket; Infinitesimal canonical transformations; Hamilton-Jacobi's equation.	20
Unit-6	Variational Calculus: Brachistochrone problem, geodesic, Euler-Ostrogradsky equation, Isoperimetric problem, Variational problems with moving boundaries, Sufficient conditions for extrema, Jacobi's condition, Legendre condition. Direct method to solve variational problem, Rayleigh-Ritz method to find approximate solution.	10
Total Contact Hours		75

Text Books

1. H. Goldstein, Classical Mechanics. Narosa Publ., New Delhi.
2. N. C. Rana and P. S. Joag, Classical Mechanics, Tata McGraw Hill, New Delhi.
3. A. S. Gupta, Calculus of Variations with Applications, Prentice Hall, India

Reference Books

1. F. Chorlton, Text Book of Dynamics, CBS Publishers.
2. J. L. Synge and B.A. Griffith, Principles of Mechanics, McGraw-Hill, N.Y.
3. R.G. Takwale & P.S. Puranik, Introduction to Classical Mechanics, Tata McGraw Hill.
4. L. D. Elsgolc, Calculus of Variations, Dover Publications, New York.
5. I. M. Gelfand and S.V. Fomin, Calculus of Variations, Prentice Hall Inc.

CO–PO–PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	H	H	L	L	L	—	M	M	H	L	M	M
CO2	H	H	M	L	L	—	M	M	H	M	M	H
CO3	H	H	M	L	L	—	M	M	H	M	H	H
CO4	H	H	M	L	L	—	H	M	H	M	H	M
CO5	H	H	M	L	L	—	M	M	H	M	H	H

Major coursework-8

[Go to Course Structure](#)

Course Code: MSCMTMMC204	Course Name: Operations Research			
Course Type: MAJOR COURSEWORK (Theoretical)	Course Details: MC-8		L-T-P: 4-1-0	
Credit: 5	Full Marks: 100	CA Marks		ESE Marks
		Practical	Theoretical	Practical Theoretical
		.....	30	 70

Pre-requisite of course	A basic knowledge of calculus, linear algebra, and linear programming problems.		
Course Objectives			
The objectives of this course are to: 1. Develop an understanding of game theory and its applications in decision-making. 2. Introduce the fundamental concepts and solution techniques of integer programming, including cutting-plane methods and branch-and-bound algorithms. 3. Provide knowledge of nonlinear and quadratic programming techniques for solving constrained and unconstrained optimization problems. 4. Explain the principles of inventory control and develop the ability to formulate and analyze deterministic and probabilistic inventory models. 5. Familiarize students with queuing theory, including Poisson processes, queuing system characteristics, and the analysis of standard queuing models.			
Course Outcomes (COs)			
Upon successful completion of this course, students will be able to:			
CO1	Formulate and solve two-person zero-sum games using mixed strategies, dominance principles, graphical methods, algebraic methods, and linear programming techniques.		
CO2	Apply integer programming techniques, including Gomory’s cutting-plane methods and branch-and-bound algorithms, to solve integer optimization problems.		
CO3	Formulate and solve nonlinear and quadratic programming problems using various methods.		
CO4	Formulate and analyze deterministic and probabilistic inventory models to determine appropriate inventory policies under different shortage and demand conditions.		
CO5	Analyze queuing systems using the properties of Poisson processes and apply appropriate queuing models to evaluate system performance and support operational decision-making.		
Course content			Contact

		Hours
Unit-1	Game theory: Formulation of two-person zero sum games, solving two-person zero sum games, games with mixed strategies, Rectangular and square games, Concept of Dominance, graphical solution procedure, Algebraic method of solution, linear programming solution of games.	15
Unit-2	Integer Programming: Standard form of Integer Programming, The concept of cutting plane for linear integer programs, Gomory's cutting plane method, Gomory's All-Integer Programming Method, Branch-and-Bound Algorithm for general integer programs.	10
Unit-3	Non-linear Programming: Formulation of Non-linear programming problem, Unconstrained optimization, Optimization with equality constraints, Kuhn-Tucker conditions for constrained optimization. Quadratic Programming: Wolfe's modified simplex method, Beale's method. Convex Programming.	15
Unit-4	Inventory Control: Historical background and Introduction of this topic, Nature of inventory problems, Features of inventory system, Definition of inventory problem. Important parameters associated with inventory problems, Variables in inventory problems, Inventory model building, Deterministic inventory models with-No shortage, Shortage. Discrete and Continuous probabilistic inventory models.	15
Unit-5	Queuing Theory: Introduction, Features of Queuing systems, Queue disciplines, The Poisson process (Pure birth process), Arrival distribution theorem, Properties of Poisson process, Solution of Queuing models: $\{(M/M/1):(\infty|FCFS)\}$, $\{(M/M/1):(n|FCFS)\}$, $\{(M/M/s):(\infty|FCFS)\}$, $\{(M/M/s):(n|FCFS)\}$.	20
Total Contact Hours		75

Text Books

1. J. K. Sharma; Operations Research (Theory and Applications); Macmillan.
2. Hamdy A. Taha: Operations Research-An Introduction, Prentice Hall.

Reference Books

1. Sharma, S.D., Operation Research, Kedarnath & Ramnath, Meerut.
2. T. L. Saaty, Elements of Queueing Theory, with Applications, Dover Publications Inc
3. G. Hadley, Linear Programming, Narosa Publishing House, New Delhi.
4. Rao, S.S., Optimization Theory and Application, Wiley Eastern.

CO–PO–PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	L	L	—	M	M	H	M	M	M
CO2	H	H	H	L	L	—	M	M	H	H	M	M
CO3	H	H	H	L	L	—	M	M	H	H	H	M
CO4	H	H	M	L	L	—	M	H	H	M	H	H
CO5	H	H	M	L	L	—	M	H	M	M	M	H

Minor course-2

[Go to Course Structure](#)

Course Code: MSCMTMMN201	Course Name: Graph Theory				
Course Type: MINOR COURSE (Theoretical)	Course Details: MN-2			L-T-P: 4-1-0	
Credit: 5	Full Marks: 100	CA Marks		ESE Marks	
		Practical	Theoretical	Practical	Theoretical
		.....	30	.....	70

Pre-requisite of course	A basic knowledge of discrete mathematics, set theory, and relations.		
Course Objectives			
The objectives of this course are to:			
1. Develop a fundamental understanding of graphs, their representations, connectivity, and structural properties.			
2. Introduce Eulerian and Hamiltonian graphs and their applications to network and optimization problems.			
3. Develop graph-theoretic algorithms for trees, shortest paths, and minimum spanning trees.			
4. Familiarize students with planar graphs, graph coloring, chromatic properties, and related concepts.			
Course Outcomes (COs)			
Upon successful completion of this course, students will be able to:			
CO1	Analyze graphs using paths, cycles, connectivity, graph representations, bipartite structures, and graph isomorphism.		
CO2	Characterize and analyze Eulerian and Hamiltonian graphs and apply related concepts to problems such as the Travelling Salesman Problem.		
CO3	Apply tree-based algorithms, including Kruskal’s, Prim’s, and Dijkstra’s algorithms, to solve minimum spanning tree and shortest-path problems.		
CO4	Analyze planar and non-planar graphs using Euler’s formula, Kuratowski’s theorem, and related structural properties.		
CO5	Apply vertex and edge coloring concepts to determine chromatic properties, chromatic polynomials, clique and independence parameters, and related graph structures.		
Course content			Contact Hours
Unit-1	Basic concepts: Graphs: Undirected graphs, directed graphs, basic properties of graphs, walks, paths, trails, cycles, Circuits, connected graphs, components of a graph, complete graph, complement of a graph, bipartite graphs, characterization a bipartite graph, Adjacency matrices, Incidence matrices, Isomorphism.		15
Unit-2	Graphs with special properties: Königsberg bridge problem, Eulerian Trails, Eulerian		15

	Circuits, Eulerian Graphs, characterization, Hamiltonian (Spanning) cycles, Hamiltonian graphs: Necessary conditions, sufficient conditions, Hamiltonian closure, Travelling salesman problem.	
Unit-3	Trees: Basic properties, Distance, radius and centre, Diameter, Rooted trees, Binary trees, Minimal spanning tree, Shortest path problem, Kruskal's algorithm, Prim's algorithm, Dijkstra's algorithm, Chinese Postman Problem.	15
Unit-4	Planar graphs: Planar graphs and non-planar graphs, face-size equation, Euler's formula for a planar graph. The graphs K_5 and $K_{3,3}$, Kuratowski's theorem (statement only).	10
Unit-5	Coloring of Graphs: Vertex coloring, proper coloring, k-colorable graphs, chromatic number, upper bounds, Cartesian product of graphs, Structure of k-chromatic graphs, Mycielski's Construction, Color-critical graphs, Chromatic Polynomial, Clique number, Independent (Stable) set of vertices, Independence number, Clique covering, Clique covering number, Edge-coloring, Edge-chromatic number.	20
Total Contact Hours		75
Text Books		
1. D. S. Malik, M. K. Sen and S. Ghosh: Introduction to Graph Theory, Cengage Learning Asia, 2014. 2. N. Deo: Graph Theory with Applications to Engineering and computer science, PHI, 1997.		
Reference Books		
1. D. B. West: Introduction to Graph Theory, Pearson. 2. J. Clark and D. A. Holton: A First Look at Graph Theory, Allied Publishers Ltd., 1995 3. J. A. Bondy and U.S.R. Murty: Graph Theory with Applications, Macmillan, 1976. 4. E. G. Goodaire and M. M. Parmenter, Discrete Mathematics with Graph Theory, 2nd Edition, Pearson Education (Singapore) P. Ltd., Indian Reprint 2003.		

CO–PO–PSO Mapping (High/Medium/Low)

CO #	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PSO1	PSO2	PSO3	PSO4
CO1	H	H	M	L	L	—	M	L	H	M	M	M
CO2	H	H	M	L	L	—	M	M	H	M	M	H
CO3	H	H	H	L	L	—	H	H	H	H	H	H
CO4	H	H	M	L	L	—	M	L	H	M	M	M
CO5	H	H	M	L	L	—	H	M	H	M	H	H